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13. ABSTRACT (Maximum 200 words)

This report covers the year 2003. The major results from this work were as follows: (1) New improvements of the Bayesian Maximum Entropy (BME) theory of space/time mapping, (2) new technology leading to considerable revision/improvement of the widely used BMElib library (currently used by researchers and practitioners in over 20 countries worldwide. The work has resulted in several publications in journals and books, as well as presentations at national and international meetings.

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Final report:

Substantial improvements were obtained during the last year time period for the project "Modeling and Prediction of Space/Time Natural Processes Using A Bayesian Maximum Entropy": The four main aspects that constitute a continuation of the previous years' work are:

(1) Augmentation of the BME modelling framework of informative space-time mapping developed during the early years of this ARMY project.
(2) Improvement of our highly successful, public-domain temporal GIS (TIGS) computer libraries used to implement the BME framework in real-world situations.
(3) Application of the advanced TGIS to real-world case studies of considerable importance.
(4) Enriching the real-world applicability of the TGIS by incorporating physical laws describing the natural and terrain processes of interest.

The work of this project related to modeling and prediction of space/time processes using BME has resulted in several publications in journals and books, as well as presentations at national and international meetings, as illustrated by the list of 28 relevant references of publications and presentations related to this project. Below, we briefly discuss the progress made during the past year in each of the aspects (1)-(4) above.

The BME framework provides a science-based integrated space-time modelling and prediction. The most recent version of BME is based on an innovative blending of various inter- and multi-disciplinary concepts and knowledge bases from different disciplines. In the past year we continue to improve our BME approach by means of, (a) the rigorous analysis of a wide range of natural processes, (b) the stochastic assessment of individual sources of uncertainty, (c) the development of new classes of non-separable covariance models representing important correlations of the natural systems across space-time. Our analysis uses the powerful modeling techniques developed by our group during the earlier years of the ARO project in order to study the space-time distribution of natural and terrain processes [Bayesian Max Entropy (BME), Material Biconditional Max Fisherian (MbMF), stochastic PDE etc. techniques]. This year we also studied an advection-reaction model generating probability distributions of natural variables in a spatiotemporal domain.

As previously indicated, the last year we added an additional objective to our research effort. This new objective consist in improving the conceptual foundations of our space-time models by incorporating in the analysis framework any physical and laws describing the environmental and health process of interest. We made substantial progress with this objective, which resulted in the derivation of a conceptual framework, and it's application in the case of physical equations governing subsurface flow. We published articles describing this framework and it's application for subsurface flow. This is an area with considerable interest for ARO applications, as well as for wide ranging applications in multidisciplinary areas.

During this year, we continued to maintain and further develop our highly successful computational TGIS libraries. These libraries include BMElib, which is a numerical implementation of advanced functions of Temporal Geographic Information Systems (TGIS), as well as the SANlib, which focuses on applications dealing with non-homogeneous/non stationary terrain processes. We continuously update our state of the art website available to modellers from around the world. This one-of-its-kind website makes it possible that all those interested in spatiotemporal modelling and mapping can benefit from the models and tools developed by our group (free downloading of high quality computational libraries, documents, models, tools, numerical examples and case-studies etc.). This website allows us to work more efficiently, to foster collaborative efforts with other research groups interested in applying our ideas and methods, and enables us to have access to wider sources of data and expertise.